eg. Carbon 14 has a half-life of 5730 years.

a) what is the decay constant?
$\lambda = \ln 2 / t_{1/2}$ = 0.693/5730=1.21x10^{-4} a^{-1}

b) what is the probability of a particle nucleus decaying in a year?
1.21x10^{-4} per year

c) you measure a sample and it has an activity of 3.0 x10^{3} decays per second. How many C 14 atoms are in the sample?
$dN/dt = -\lambda N$ N=3000decays/s/1.21x10^{-4}a^{-1}
3000/0.000121=2.479339E7
2.479339E7x(365.25x24x3600)=7.824199E14
7.8x10^{14} atoms

d) if the sample is 40 000 years old (3 sig figs), how many atoms were in the original sample?
$N = N_0 e^{-\lambda t}$ $N_0 = N / e^{-\lambda t}$ =
7.824E14/(e^(-0.000121x40000))=
9.89x10^{16} atoms

e) if a sample of C 14 is reduced to 1/32 of the original sample how old is the sample?
5x5730=28650 =29 000 years old

f) if a sample of C 14 is reduced to 0.000000123453 of the original sample how old is the sample?
$y = e^x$ $\ln y = x$

$N/N_o = e^{-\lambda t}$
$\ln (N/N_o) = -\lambda t$
$t = [\ln (N/N_o)]/-\lambda$
$t= [\ln(0.000000123453)]/(-0.000121)=$
1.3×10^5 years old

p1116 problems 17, 25, 57, 59, 65, 69

When anti-matter hits equivalent matter it annihilates - changes into energy.

How much energy? $E=mc^2$
c is speed of light, 3.00×10^8m/s
When an electron hits a positron (each of mass 9.11×10^{-31}kg) what is the minimum energy of the released photons? Why do I say minimum?

$E= mc^2 = 9.11\times10^{-31}\text{kg}\times2\times(3.00\times10^8\text{m/s})^2$
$= 1.64\times10^{-13}$J
$\text{MeV} = 1.602\times10^{-13}$ J (alternate units)
so E=1.0MeV

The released photons must obey conservation laws:
conservation of energy, energy of the photons = mass energy + kinetic energy
conservation of momentum - so the momentum of

the photons $p=h/\lambda = hf/c$ must equal the momentum of the electron and positron.

Binding energy

The mass of a proton is 1.007276u
the mass of neutron is 1.008665 u
u is the atomic mass unit, $1u = 1.661 \times 10^{-27}$kg
defined as 1/12 the mass of a carbon 12 nucleus.
Hey, wait.
Carbon 12 = 12.0000000000000000000000 u
but Carbon 12 is 6 protons and 6 neutrons
6x(1.007276)+(6x1.008665)=12.095646 u
What's the deal?
where did the 12.095646-12=0.095646u of mass go?
Nuclear Fusion in stars is where small nuclei fuse together to form bigger nuclei and give off lots of energy. Where did the energy come from? The mass lost between the reactants and products of the reaction.

Binding Energy - energy released when a nucleus is formed from constituents. It is also the energy required to pull the nucleus apart into its constituents.

Calculate the Binding energy = mass defect in u x conversion factor 931 MeV/u.

for Carbon 12 mass defect = 12.09564-12= 0.09564 u
Binding energy = 0.09564x931.5=89.0MeV

(derive 931.5MeV/u from $E=mc^2$ = $1.661x10^{-27}kgx(2.9979x10^8m/s)^2$ = $1.661x9=14.949\ x10^{-11}J\ /1.602x10^{-13}J/MeV$ =931.5MeV for every u)

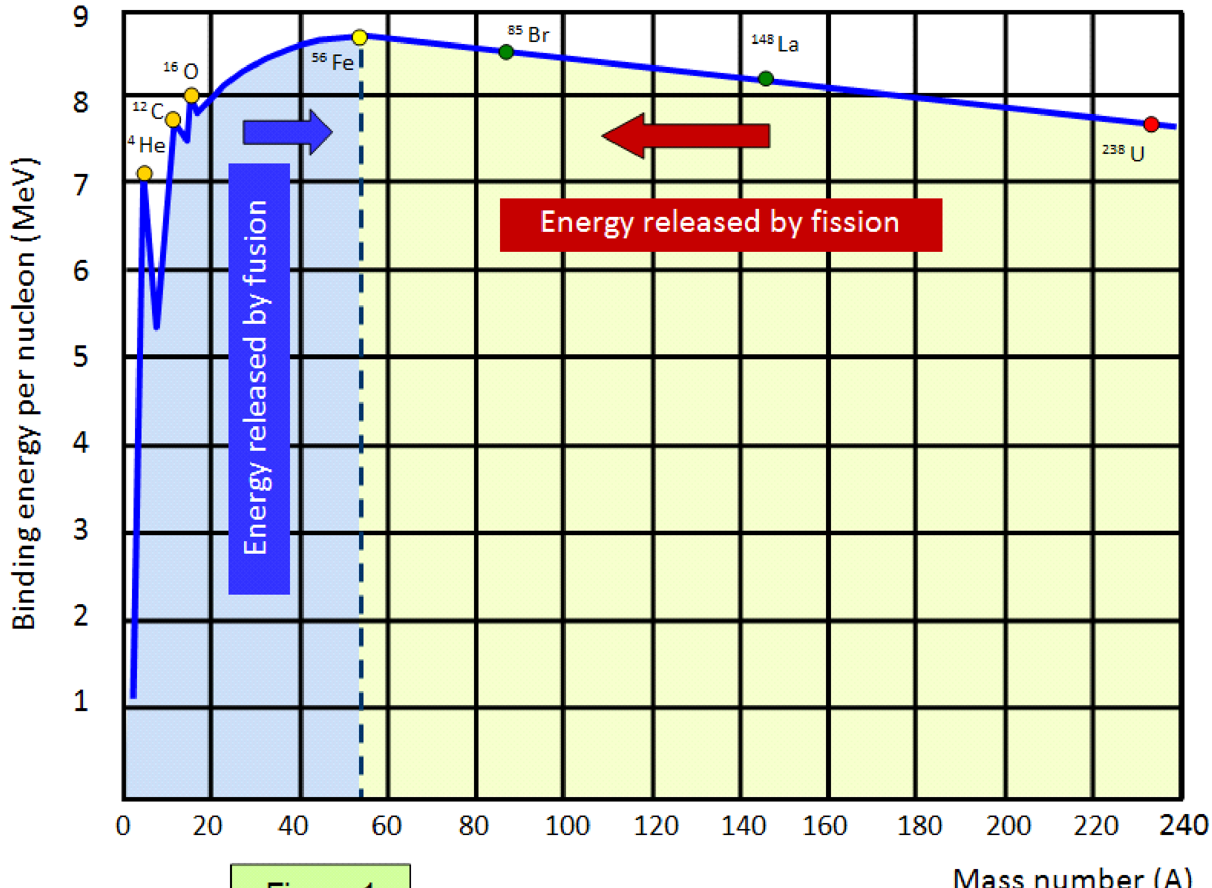

Figure 1

Note the Fe56 is given as the highest binding energy per nucleon - Fe56 is the largest nucleus produced in stars - larger atoms are produced in supernovae

Fission is when large nuclei break into 2 smaller daughter nuclei.

Fissionable materials: Uranium 235, used for Hiroshima bomb and in most nuclear reactors.

Plutonium 239 was used in Nagasaki bomb and most modern nuclear bombs. Not natural, created by bombarding uranium 238 with neutrons.

In nature Uranium is mostly uranium 238, and enriching uranium by separating 235 from 238 is difficult because they have the same chemical properties.

Thorium can be fissionable if bombarded with neutrons - good candidate because it is cheap and plentiful and harder to make into a bomb.

eg. What is the binding energy of tritium, isotopic mass of 3.01602931u (tritium is H 3, 2 neutrons one proton)?

From <https://www.google.ca/webhp?sourceid=chrome-instant&ion=1&espv=2&ie=UTF-8#q=isotopic+mass+of+tritium&*>

p116-118

Problem 26,27,28,29, 41, 47, 52, 75

$$[1(1.007276) + 2(1.008665)) - (3.01602931)](931.5\ MeV/u)$$

$-(3.0160293)]]\,($ [illegible]

$= 7.989\ \text{Mev}$

binding energy/nucleon =
7.989/3=2.663